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Meteorological aspects of lamb mortality at Bradfield 1978

Agricultural Memorandum 849

Materials & methods

This season (1978) the extensive recording network used previously (Agricultural Memoranda 835,845) was replaced by automatic recording of wind-run and temperature (near lamb height) and rainfall at the reference site. Continuous recording enabled an estimate of heat loss elicited by the environment over short time scales (order of hours); the run-of-wind 'roses' compiled last season allowed 'reference site' data to be extrapolated to other sites if required.

The question remained of how representative the data were for the mobile lamb situation. Also the dead lambs were recovered once daily; this limited the time-of-death estimates to basically a 'day-of-death' and the assumption was made that all lambs died about midnight - some 8 hours before bodies were retrieved.

Climatological 'stresses' were taken as those estimated from measurements at the reference site.

The rate of metabolic heat production in homeothermic animals such as lambs increases in response to an increase in heat loss to the environment - in order that body temperature can be stabilised. Heat loss increases as environmental temperature falls and as air movement and/or evaporation from the coat increase. This continual erosion of energy reserves from an already undernourished or sick lamb is recognised (Blaxter, etc) as contributing to the incidence of deaths in young lambs and in severe climatic situations (experienced on hill farms for example), might be the primary cause of death.

Field deaths in young (less than 10 days) Bradfield lambs were associated with low, generally negative weight increments (birth to death). We might regard this as indicating

that the plane of nutrition was less than maintenance which could lead to the cold/ starvation syndrome referred to by Slee (1976). The inference is that for these lambs the critical temperature (below which metabolic output must be increased to maintain homeothermy) was an average close to the ambient temperature.

Data by Alexander (1964) provide a basis for expressing environmental variables in terms of heat loss. Thus heat loss for a young, dry 2kg lamb in still air at $-32^{\circ}C$ is apparently the same as that for the same lamb, wet in a 5.5 ms^{-1} (12 mph) wind at $+13^{\circ}C$. The influence of wind and particularly a wetted coat are clear.

The meteorological data were analysed in terms of the metabolic response elicited by the environment over 4 hour periods. Alexander's data for young (Merino) lambs were taken as applicable to the breeds of the Bradfield flock and of ages upto 10 days (considered reasonable by Alexander & Slee in personal communications).

(Even if Alexander's data are not correct absolutely they still provide a means of estimating days of relatively high and low climatic stress).

Heat losses were estimated, for the observed combination of wind and rainfall over 4 hour periods and were expressed in terms of the basal metabolic rate, M_B. The losses were then summed over the 24, 48 and 72 hours prior to death.

Thus each 4 hour period elicits a heat loss, M(4), from the lamb [and $M(4) = a.M_B$ where a lies between about 1.5 and 5 for the observed Bradfield met. variables].

Also M(4) is a function, f, of temperature T, wind speed, V, and state-of-coat, S (ie wet or dry).

Thus $M(4) = f(T,V,S) = a.M_B$

Over 24 hours (6 four hour periods, t)

$$M = \frac{1}{6} \sum_{t=1}^{t=6} M(4) = \frac{M_B}{6} \sum_{t=1}^{t=6} a$$

and over the 48 and 72 hours prior to death:

$$M = \frac{M_B}{12} \sum_{t=1}^{t=12} a \quad ; \quad \frac{M_B}{18} \sum_{t=1}^{t=18} a \qquad \text{respectively}$$

The Kolmogorov-Smirnov one-tailed test* was used to test the significance between 'observed' lamb deaths (ascribed to weather stress) and the 'expected' deaths based on the relative frequency of occurrence of periods of various heat demand.

Significance of deaths was against the magnitude of the weather stress on the day of death and over the two and three days prior to death. Tests were applied to the March period alone (when the majority of lambs dying were less than 10 days old) and to the remaining period to early May (when the age of dead lambs was in the range 20 to 60 days).

Meteorological data commences on 9th March (when lambs were put out) and terminates on 8th May (after which few lamb deaths occurred).

Results

Table 1a shows the observed and expected distribution of lamb 'stress' deaths among the estimated daily M values for the two periods.

a) 9 March to 1 April

b) 2 April to 8 May

The application of the Kolmogorov-Smirnov test is shown.

Tables 2 and 3 show the 'stress' deaths related to the M values summed over 2 and 3 days respectively.

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*This test makes no assumptions about the population from which samples are drawn and is not limited by small samples. The test involves specifying the cumulative frequency distribution and the expected distribution and comparing this with the observed cumulative frequency distribution (see Table 1). Ref: Siegel, S, Non-parametric Statistics, MaGraw Hill, 1956.

Inspection of the data in Table 1a shows there is a trend for more deaths than expected to be associated with the higher stress end of the table.

eg

	M<17.5	M>17.5
observed	6	14
expected	8.7	11.3

The null hypothesis being tested then is that there is no difference between the probability of occurrence between the observed and expected lamb deaths.

The Bradfield lambs are housed during the first day when cold stress is undoubtedly a critical factor to survival.

An older lamb will be better adapted to survive weather stress; further the more moderate climate of the South East will impose less stress than in an Upland Farm situation.

We should not then anticipate a very high death/weather significance eg at the 1% or 0.1% level; rather we might look for a 'trend' (illustrated in the above table) and significant at the 10% level or below.

In fact Table 1a indicates a 7% level of significance. No significance obtains for Table 1b and Tables 2 and 3.

Summary

The Bradfield 1978 data indicates that there appears to be a significant tendency for young lamb deaths to be related to weather stress on the day of death.

Bradfield weather 1978 (see fig 1)

The mild spell at the end of February continued into the first week of March under the influence of fresh to strong south-easterly winds.

In mid-March after a wet night on 15/16th the temperature dropped sharply in a cold north-westerly air-stream and a belt of snow affected the area, followed by wintry

showers until the 17th.

North-westerly gales occurred on the 20th and wind continued fresh to strong until the 29th.

Summary for March: windy and unsettled; temperatures mostly above normal but wintry at times.

The first four days of April were dull and misty with rain or drizzle, then a sunny north-easterly régime set in on the 4th; early on the 10th a very cold northerly air stream set in after a cold front crossed the area and a wintry spell followed with overnight frosts and moderate snow.

Summary for April: (coldest since 1956) cold, north-easterly winds predominated. Mostly cold or very cold with wintry conditions during the second week.

May started wet and cool but the second half was dry, sunny and very warm.

References

Alexander G (1964) Proc. Austr. Soc. of Anim Prod. 5, 113-122

Blaxter KL, Joyce JP and Webster AJF (1964) 2nd Symposium on Shelter Res. Edinburgh p 27-35

Slee J (1977) ABRO Report p11-16

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Any comments or suggestions on this paper should be referred to the author.

Legend

Figure 1

Lamb field deaths displayed against various meteorological parameters measured over 4 hours at Annis Field (reference site) and M, the heat production elicited by the environment. Data shown up to early May.

Tables

Observed and expected distribution of lamb deaths among the estimated M values.

1 a : M on the day of death, 9 March to 1 April 1978

b : M on the day of death, 2 April to 8 May 1978

2 a : M summed over two days before death, 9 March - 1 April

b : " " " " " " " , 2 April - 8 May

3 a : M summed over three days before death, 9 March - 1 April

b : " " " " " " " , 2 April - 8 May

Units M in Kcal. $m^{-2}hr^{-1}$ when multiplied by factors indicated

Table 1a

M (x10)Kcal. $m^{-2}hr^{-1}$	12	13	14	15	16	17	18	19	20	21	22	23	Total
Frequency of M's	1	1	2	3	2	3	2	5	1	3	1		24 days
Observed Stress deaths	0	0	0	4	2	0	0	6	0	6	2		20
Expected " "	0.8	0.8	1.7	2.5	1.7	2.5	1.7	4.2	0.8	2.5	0.8		
O-E	-0.8	-0.8	-1.7	1.5	0.3	-2.5	-1.7	1.8	-0.8	3.5	1.2		
Σ (O-E)	-0.8	-1.6	-3.3	-1.8	-1.5	-4.0	-5.7	-3.9	-4.7	-1.2	0		

$$D = \frac{\text{Max}|\Sigma(O-E)|}{N} = 5.7/20 = 0.285$$

From Statistical tables P (10%) = 0.264
P (5%) = 0.294
Thus Distribution is Significant at about the 7% level.

1b

M	12	13	14	15	16	17	18	19	20	21	22	Total
Frequency of M's	3	1	4	8	3	11	3	2	0	2		37 days
Observed Stress deaths	2	0	1	4	1	4	1	0	0	2		15
Expected " "	1.22	0.40	1.62	3.25	1.22	4.46	1.22	0.81	0	0.81		
O-E	0.78	-0.40	-0.62	0.75	-0.22	-0.46	-0.22	-0.81	0	1.19		
Σ(O-E)	0.78	0.38	-0.24	0.51	0.29	-0.17	-0.39	-1.20	-1.20	$\sim$0		

$$D = \frac{\text{Max}|\Sigma(O-E)|}{N} = 1.20/15 = 0.08$$

P (20%) = 0.266

Distribution is not significant

Table 2a

M_1+M_2 (x5)	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	Total
Frequency of M's	1	0	1	0	0	1	1	2	1	1	2	1	4	2	3	1	2		23
Observed Stress deaths								2	0	2	5	0	2	5	1	0	3		20
Expected " "	0.87	0	0.87	0	0	0.87	0.87	1.74	0.87	0.87	1.74	0.87	3.48	1.74	2.61	0.87	1.74		

$D = \frac{\text{Max}|\Sigma(O-E)|}{N} = \frac{4.09}{20} = 0.205$ and P(20%) = 0.231 : Not Significant

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2b

	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	Total
Frequency of M's		0	2	5	0	2	2	6	5	7	5	0	0	1	0	2		37
Observed Stress deaths						4	2	1	2	3	1	0	0	1	0	1		15
Expected " "			0.82	2.05	0	0.82	0.82	2.46	2.05	2.87	2.05	0	0	0.41	0	0.82		

$D = 2.87/15 = 0.191$ and P(20%) = 0.266 : Not Significant

Table 3a

$M_1+M_2+M_3$ (x3⅓)	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	Total
Frequency of M's	1	0	0	1	0	0	0	0	0	0	1	1	3	6	0	2	2	2	0	1	1	1		22
Observed stress deaths											2	0	5	7	0	2	0	1	0	2	1			20
Expected " deaths	0.91			0.91							0.91	0.91	2.73	5.45	0	1.82	1.82	1.82	0	0.91	0.91	0.91		

$D = \frac{2.46}{20} = 0.123$ and P(20%) = 0.231 : Not Significant

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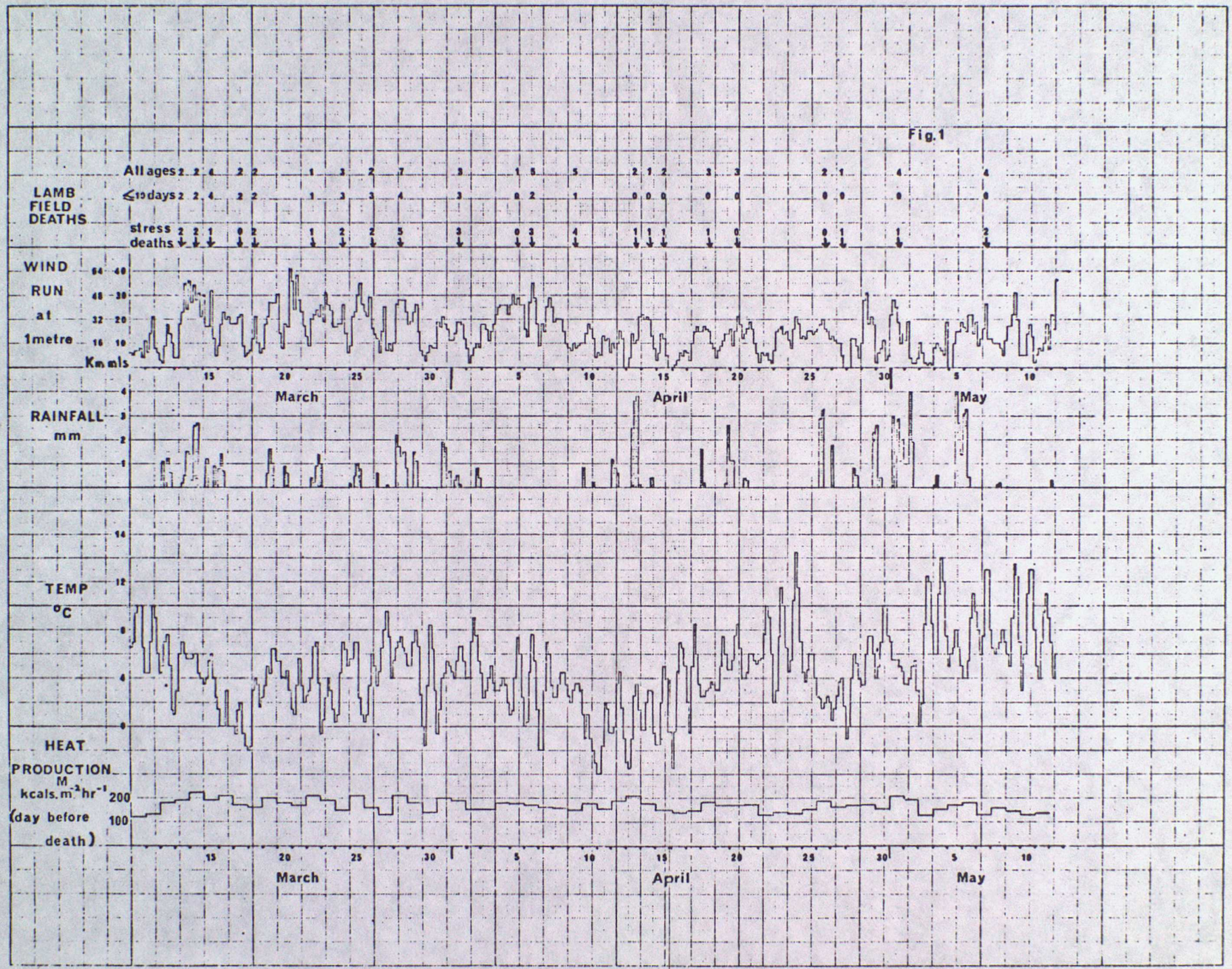
3b

	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	Total
Frequency	1	0	0	2	1	1	1	6	3	3	5	4	4	2	1	2	0	0	1		37
Observed deaths								5	2	0	1	3	1	1	0	1	0	0	1		15
Expected "	0.41			0.82	0.41	0.41	0.41	2.43	1.21	1.21	2.03	1.62	1.63	0.82	0.41	0.82	0	0	0.41		

$D = \frac{2.46}{15} = 0.164$ and P(20%) = 0.266 : Not Significant

Fig.1


LAMB FIELD DEATHS
All ages 2 2 4 2 2 1 3 2 7 3 1 5 5 2 1 2 3 3 2 1 4 4
≤10 days 2 2 4 2 2 1 3 3 4 3 0 2 1 0 0 0 0 0 0 0 0 0
stress deaths 2 2 1 0 2 1 2 2 5 3 0 3 4 1 1 1 1 0 0 1 1 2
WIND RUN at 1 metre
64 48 32 16
40 30 20 10
Kms
15 20 25 30 5 10 15 20 25 30 5 10
March
April
May
RAINFALL mm
4 3 2 1
TEMP °C
14 12 8 4 0
HEAT PRODUCTION
M kcals.m⁻².hr⁻¹
200 100
(day before death)
15 20 25 30 5 10 15 20 25 30 5 10
March
April
May